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HYDROTHERMAL SYNTHESIS OF VEATCHITE
AND ITS CALCIUM ISOMORPH,

C. R. PARKERSON

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ABSTRACT

→ The hydrated strontium borate, veatchite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), and its calcium isomorph ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) have been prepared by hydrothermal synthesis at 260°C . Veatchite was prepared by the reaction of $\text{Sr}(\text{OH})_2$ and H_3BO_3 solution and also by the conversion of tunellite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$) in H_3BO_3 solution at 260°C . The calcium isomorph was prepared in a similar manner by the reaction of $\text{Ca}(\text{OH})_2$ and H_3BO_3 solution and also by the conversion of gowerite ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) in H_3BO_3 solution at 260°C . The observed densities of the synthetic veatchite and the calcium isomorph, as determined with a pycnometer and using water as the liquid, were 2.77 ± 0.04 and 2.31 ± 0.02 g/cc respectively, for 0.5-g samples of fine crystals. The highest and lowest indices of refraction (white light) for the synthetic veatchite and its calcium isomorph were determined to be 1.546 and 1.619 ± 0.003 , and 1.555 and 1.620 ± 0.002 , respectively. ←

FOREWORD

The Naval Ordnance Laboratory Corona is making a continuing study of the chemistry and synthesis of crystals of ferroelectric colemanite ($2\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$), its strontium isomorph ($2\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$), and other related calcium and strontium borate hydrates of potential use in ferroelectric devices. As part of this study, the chemistry and methods of synthesis of veatchite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) and its calcium isomorph ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) are reported herein. The dielectric, ferroelectric, and pyroelectric properties of the materials synthesized will be reported later. All the above work is authorized by ONR Contract PO 1-0008 NR 048-119.

C. J. HUMPHREYS
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INTRODUCTION

The synthesis of colemanite single crystals in 1959 and the preparation of deuterated colemanite in 1961 have been reported in NOLC Technical Memorandums (Refs. 1, 2, 3), and in 1962 a comparison of the ferroelectric and pyroelectric properties of mineral and synthetic colemanite was made (Ref. 4). The synthesis of the hydrated calcium borates was then investigated further to improve the quality and size of the crystals produced, and a limited study was made of the hydrothermal reactions that produce hydrated calcium and strontium borates and the transformation these borates undergo with increased temperature.

The work reported in this document is only a small part of the overall investigation of the calcium and strontium borate hydrates that might prove of interest to those people who are concerned with ferroelectric devices. Since, to the author's knowledge, there has been no previous laboratory synthesis of the mineral veatchite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), and no mention of the existence of a calcium isomorph ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), this work is considered sufficiently important to be reported separately from the results of the entire investigation, which will appear in a report now in process of publication (Ref. 5).

PREPARATION OF SYNTHETIC VEATCHITE

It was found that synthetic veatchite could be prepared by two methods. By the first method, strontium hydroxide is reacted with boric acid in aqueous solution at 260°C for 64 hours. By the second method, the veatchite is prepared by the transformation of synthetic "tunellite" ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$) in boric acid solution at 260°C for 40 hours. The second method produces the best quality of crystals.

Method I. Reaction of $\text{Sr}(\text{OH})_2$ and H_3BO_3 . In this method and also in Method II, the reaction is carried out in a sealed, stainless steel bomb, which has a capacity of 76 ml and is equipped with a platinum liner. The platinum liner is not absolutely necessary, but it serves to reduce the contamination of the product. The reaction mixture consists of 8.50 ml H_2O (CO_2 free), 1.42 g anhydrous SrO , and 7.30 g boric acid

crystals. The reaction is completed within 64 hours at 260°C to form veatchite.

Method II. Transformation of tunellite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$) in boric acid solution. The reaction mixture consists of 22.6 ml H_2O (CO_2 free), 1.89 g synthetic tunellite, and 4.52 g boric acid crystals. The reaction is completed within 40 hours at 260°C to form veatchite. In the absence of boric acid, this reaction does not produce veatchite.

Table 1 gives the X-ray diffraction analysis for both the synthetic veatchite produced by the above methods and the calcium isomorph of veatchite discussed below. For comparison purposes, X-ray data are presented from investigations of the mineral veatchite by others (Refs. 6, 7, 8).

PREPARATION OF THE CALCIUM ISOMORPH OF VEATCHITE

Reactions similar to those described above produce the calcium isomorph ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$). The reactions are identical, except that for Method I an equivalent amount of $\text{Ca}(\text{OH})_2$ is substituted for the SrO , and in Method II gowerite ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) is substituted for tunellite. The reaction time is reduced to 40 hours at 260°C in the formation of the calcium compound, since longer reaction time favors the formation of other reaction products. See Table 1 for the X-ray diffraction data for the synthetic calcium isomorph produced by these reactions. Details of other reaction times and resultant products will be published in the forthcoming report on the entire investigation (Ref. 5).

This isomorph can also be produced by the conversion reaction of synthetic ginorite ($2\text{CaO} \cdot 7\text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$) in boric acid solution in a manner identical with that given for the transformation of gowerite. In the presence of boric acid solution of the strength used in the above reactions, gowerite is completely transformed to ginorite at 170°C and to the veatchite isomorph at 260°C.

The compound $\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ is also one component of the reaction product resulting when a mixture containing 0.20 g colemanite and 1.00 g priceite is reacted for 5 days at 200°C with 50 g of 20% boric acid solution in a 76-ml bomb. The second component of this reaction product will be discussed in the report cited in Ref. 5.

DENSITY AND REFRACTIVE INDEX OF SYNTHETIC VEATCHITE AND THE CALCIUM ISOMORPH

Two determinations of density were made with a pycnometer on separate samples of the synthetic veatchite crystals, using water as the liquid. The values obtained for the two specimens (approximately 0.5 g each) of fine crystals were 2.73 and 2.80 g/cm³. This compares favorably with the value of 2.78 ± 0.03 reported by Clark, Mrose, Perloff, and Burley (Ref. 6).

Two determinations of density of the synthetic $\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ were also made by the pycnometer method. The values obtained for the two specimens (approximately 0.5 g each) of fine crystals were 2.29 and 2.32 g/cm³.

The highest and lowest refractive indices were determined for the synthetic veatchite and $\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ by using the immersion method and white light. The values for synthetic veatchite are 1.546 and 1.619 (± 0.003), and for the calcium isomorph, 1.555 and 1.620 (± 0.002).

TABLE 1. X-Ray Powder Data for Synthetic Veatchite, the Calcium Isomorph of Veatchite, and Mineral Veatchite

Synthetic Veatchite—Parkerson, 1963	Calcium Isomorph of Veatchite—Parkerson, 1963		Mineral Veatchite		
	Stewart, Chalmers, and Phillips, 1954	Kramer and Allen, 1956	Clark, Mrose, Perloff, Burley, 1959		
(measured)	(measured)	(measured)	(measured)	(calculated)	
I d_{hkl}	I* d_{hkl}	I d_{hkl}	I d_{hkl}	d_{hkl}	hkl
100 10.5	vs ¹ 10.3	10 10.53	100 10.5	10.40	200
5 5.68	m 5.65	1 5.63	6 5.64	5.870	020
1 5.43				5.775	011
4 5.15	m 5.13	3 5.22	6 5.12	5.649	120
1 4.79				5.609	$\bar{1}11$
1 4.52				5.521	111
1 4.46	w 4.47			5.199	400
1 4.13				5.115	$\bar{2}11$
2 3.88				5.112	220
2 3.83				4.985	211
1 3.67	m 3.88		2 4.51	4.505	$\bar{3}11$
22 3.48	w 3.48			4.480	320
				4.372	311
				3.924	$\bar{4}11$
				3.892	420
				3.807	411
				3.466	600
				3.425	$\bar{5}11$

(Contd.)

NOTE: Footnotes are at end of table.

TABLE 1. (contd.)

Synthetic Veatchite— Parkerson, 1963		Calcium Isomorph of Veatchite— Parkerson, 1963		Mineral Veatchite			
				Stewart, Chalmers, and Phillips, 1954	Kramer and Allen, 1956	Clark, Mrose, Perloff, Burley, 1959	
(measured)	I d_{hkl}	(measured)	I d_{hkl}	I^* d_{hkl}	(measured)	I d_{hkl}	(measured) d_{hkl} (calculated)
9 3.37						3 3.37	3.394 520 3.370 031 3.336 131
3.33	14 3.28			vs^2 3.33	2 3.32	35 3.32	$\left. \begin{matrix} 3.328 \\ 3.318 \\ 3.316 \end{matrix} \right\}$ 511 131 002
1 3.23	>1 3.22			w 3.20		3 3.22	3.223 231 3.192 202
>1 3.15	>1 3.14 3 3.09 3 3.05						3.190 231 3.128 202 3.053 331
1 3.02							$\left. \begin{matrix} 3.013 \\ 3.010 \\ 2.985 \end{matrix} \right\}$ 611 331 620
1 2.986	>1 2.995			wb 2.99		3 _b 3.00	$\left. \begin{matrix} 2.935 \\ 2.933 \end{matrix} \right\}$ 040 611
1 2.938	>1 2.947					2 2.936	2.906 140 2.887 022
8 2.864	3 2.882			m 2.87	3 2.88	9 2.865	2.872 122 2.851 431

NOTE: Footnotes are at end of table.

TABLE 1. (contd.)

Synthetic Veatchite— Parkerson, 1963	Calcium Isomorph of Veatchite— Parkerson, 1963	Mineral Veatchite			
		Stewart, Chalmers, and Phillips, 1954	Kramer and Allen, 1956	Clark, Mrose, Perloff, Burley, 1959	
(measured)	(measured)	(measured)	(measured)	(measured)	(calculated)
I d _{hkl}	I d _{hkl}	I* d _{hkl}	I d _{hkl}	I d _{hkl}	d _{hkl} hkl
	2 2.846				2.848 122
2 2.820	5 2.812				2.841 402
2 2.803				1 2.798	2.825 240
					2.806 431
2 2.778		vw 2.77	2.76	1 2.763	2.804 222
>1 2.704		vw 2.70	2.67	1 2.704	2.761 222
					2.753 402
>1 2.673	1 2.642				2.703 340
					2.695 322
					2.675 711
					2.651 720
					2.642 531
					2.637 322
25 2.605	24 2.569	s ³ 2.60	10 2.61	25 2.600	2.610 711
	3 2.526				2.600 800
		vw 2.53		1 2.564	2.596 531
1 2.486	1 2.486				2.558 422
1 2.434	1 2.453			1 2.495	2.556 440
					2.492 422
					2.439 602

(Contd.)

NOTE: Footnotes are at end of table.

TABLE 1. (contd.)

Synthetic Veatchite — Parkerson, 1963		Mineral Veatchite			
Calcium Isomorph of Veatchite — Parkerson, 1963		Stewart, Chalmers, and Phillips, 1954	Kramer and Allen, 1956	Clark, Mrose, Perloff, Burley, 1959	
(measured)	(measured)	(measured)	(measured)	(measured)	(calculated)
I d _{hkl}	I d _{hkl}	I* d _{hkl}	I d _{hkl}	I d _{hkl}	d _{hkl} hkl
3 2.399	m 2.39	m 2.39	1 2.40	6 2.398	2.438 631 2.406 522 2.398 540, 811 2.395 631 2.377 820 2.356 602 2.344 811 2.339 522
1 2.372					
1 2.252	1 2.274			2 2.245	
5 2.204	1 2.252	m 2.20	1 2.21	3 2.204	
4 2.164	>1 2.174		1 2.17	2 2.171	
4 2.154	3 2.154	w 2.151	1 2.16	2 2.155	
2 2.130	1 2.125			2 2.115	
2 2.120		m 2.082	9 2.08	6 2.079	
8 2.079		m 2.037		4 2.045	
5 2.043	4 2.047	vw 1.996		4 2.029	
5 2.030	2 2.021			3b** 1.958	
4 2.009	3 1.996	m 1.936	1 1.924	3 1.925	
1 1.980		vw 1.863		2 1.876	
1 1.959	2 1.967			2 1.854	

(Contd.)

NOTE: Footnotes are at end of table.

TABLE I. (contd.)

Synthetic Veatchite — Parkerson, 1963		Calcium Isomorph of Veatchite — Parkerson, 1963		Mineral Veatchite						
				Stewart, Chalmers, and Phillips, 1954	Kramer and Allen, 1956	Clark, Mrose, Perloff, Burley, 1959				
(measured)	I d _{hkl}	(measured)	I d _{hkl}	(measured)	I d _{hkl}	(measured)	I d _{hkl}	(calculated)	d _{hkl}	hkl
				I* d _{hkl}						
2	1.943			vw 1.836		1	1.833	2	1.828	
2	1.928			vw 1.801				4	1.784	
1	1.905			wb 1.761		2	1.735	1	1.730	
1	1.868	1	1.854					1	1.700	
1	1.843	1	1.833	vw 1.676				1	1.680	
1	1.836	1	1.819	vw 1.653				3	1.660	
1	1.783	1	1.783							
1	1.763	1	1.760							
1	1.732									
>1	1.714	1	1.708							
1	1.674									
2	1.657	1	1.649							

* For the Stewart, Chalmers, and Phillips data, the order of decreasing intensities is: vs^1 , vs^2 , s^3 , mw , vw , vwv .

****b indicates broadline.**

REFERENCES

1. Naval Ordnance Laboratory Corona. Progress Report on the Synthesis of Colemanite Single Crystals, by C. R. Parkerson. Corona, California, NOLC, January 1959. (Technical Memorandum 42-24.)
2. Naval Ordnance Laboratory Corona. Progress Report on the Synthesis of Colemanite Single Crystals, by C. R. Parkerson. Corona, California, NOLC, June 1959. (Technical Memorandum 42-31.)
3. Naval Ordnance Laboratory Corona. Preparation of Deuterated Colemanite, by C. R. Parkerson. Corona, California, NOLC, September 1961. (Technical Memorandum 42-56.)
4. Wieder, H. H., A. R. Clawson, and C. R. Parkerson. "Ferroelectric and Pyroelectric Properties of Mineral and Synthetic Colemanite," J. Appl. Phys., Vol. 33, No. 5 (May 1962), pp. 1720-25.
5. Naval Ordnance Laboratory Corona. Hydrothermal Synthesis of Hydrated Calcium Borates, by C. R. Parkerson. (NOLC Report 584, in process.)
6. Clark, J. R., M. E. Mrose, A. Perloff, and G. Burley. "Studies of Borate Minerals (VI); Investigation of Veatchite," Am. Mineral., Vol. 44 (November-December 1956), pp. 1141-49.
7. Kramer, H., and R. D. Allen. "A Restudy of Bakerite, Priceite, and Veatchite," Am. Mineral., Vol. 41 (September-October 1956), pp. 689-700.
8. Stewart, F. H., R. A. Chalmers, and R. Phillips. "Veatchite From the Permian Evaporites of Yorkshire," Mineral. Mag., Vol. 30 (1954), pp. 389-392.

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<p>Naval Ordnance Laboratory Corona. (NOLC Report 583)</p> <p>HYDROTHERMAL SYNTHESIS OF VEATCHITE AND ITS CALCIUM ISOMORPH, by C. R. Parkerson, Research Department. 1 June 1963. 16 pp.</p> <p>UNCLASSIFIED</p> <p>The hydrated strontium borate, veatchite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), and its calcium isomorph ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) have been prepared by hydrothermal synthesis at 260°C. Veatchite was prepared by the reaction of $\text{Sr}(\text{OH})_2$ and H_3BO_3 solution and also by the conversion of tunellite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$) in H_3BO_3 solution at 260°C. The calcium isomorph was prepared in a similar manner. The observed densities of the synthetic veatchite and the calcium isomorph, as determined with a pycnometer and using water as the liquid, were 2.77 ± 0.04 and $2.31 \pm 0.02 \text{ g/cm}^3$, respectively, for 0.5-g samples of fine crystals. The highest and lowest indices of refraction (white light) for the synthetic veatchite and its calcium isomorph were determined to be 1.546 and 1.619 ± 0.003, and 1.555 and 1.620 ± 0.002, respectively.</p> <p>ONR: PO 1-0008 NR 048-119</p>	<p>1. Calcium borate—Synthesis</p> <p>2. Strontium borate—Synthesis</p> <p>3. Veatchite—Synthesis</p> <p>I. Parkerson, C. R.</p> <p>II. Title</p>	<p>Naval Ordnance Laboratory Corona. (NOLC Report 583)</p> <p>HYDROTHERMAL SYNTHESIS OF VEATCHITE AND ITS CALCIUM ISOMORPH, by C. R. Parkerson, Research Department. 1 June 1963. 16 pp.</p> <p>UNCLASSIFIED</p> <p>The hydrated strontium borate, veatchite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), and its calcium isomorph ($\text{CaO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) have been prepared by hydrothermal synthesis at 260°C. Veatchite was prepared by the reaction of $\text{Sr}(\text{OH})_2$ and H_3BO_3 solution and also by the conversion of tunellite ($\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$) in H_3BO_3 solution at 260°C. The calcium isomorph was prepared in a similar manner. The observed densities of the synthetic veatchite and the calcium isomorph, as determined with a pycnometer and using water as the liquid, were 2.77 ± 0.04 and $2.31 \pm 0.02 \text{ g/cm}^3$, respectively, for 0.5-g samples of fine crystals. The highest and lowest indices of refraction (white light) for the synthetic veatchite and its calcium isomorph were determined to be 1.546 and 1.619 ± 0.003, and 1.555 and 1.620 ± 0.002, respectively.</p> <p>ONR: PO 1-0008 NR 048-119</p>	<p>1. Calcium borate—Synthesis</p> <p>2. Strontium borate—Synthesis</p> <p>3. Veatchite—Synthesis</p> <p>I. Parkerson, C. R.</p> <p>II. Title</p>	<p>ONR: PO 1-0008 NR 048-119</p>
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